UNDERSTANDING DEEPWATER PIPELINE RISKS

Peter Carr and Ian Nash, Peritus International, discuss the business and technical risks facing the proposed Middle East to India Deepwater Pipeline, one of the deepest and longest subsea pipelines ever planned.

South Asia Gas Enterprise Pvt Ltd (SAGE), a joint venture between the Indian Siddhomal group and UK-based deep water technology companies, is actively considering building a deepwater, transnational, natural gas pipeline system from the Middle East to India. Over 2,000 TCF of natural gas reserves are held by countries with which India has a traditional trading relationship, including Qatar, Iran and Turkmenistan. The deepwater route across the Arabian Sea is the shortest distance between these huge reserves and the rapidly developing industrial heartland of India in Gujarat, and is too short for LNG to be an economic transportation option. This work builds on the extensive study of the deepwater route of the Oman to India Pipeline that was carried out in the early 1990's. The case for this route has been strengthened by more recent development work undertaken by SAGE and by the major body of deepwater design and pipelay experience accumulated over the last decade. The pipeline is to be developed by a global consortium of design and construction contractors.

Project Overview

Peritus International Ltd has been retained by SAGE to act as overall project management and pipeline design consultants for the planned Middle East to India Deepwater Pipeline (MEIDP), which will be the first of many in a corridor of pipelines that will form the final leg of a major energy supply route linking the Middle East with India. The MEIDP 610 mm ID pipeline has been sized to facilitate the delivery of 1.1 BCFD of sales quality natural gas to India.

In the baseline design case, the pipeline will originate in Oman at the Middle East Compression Station (MECS) and terminate in India at the Gujarat Pipeline Receiving Terminal (GPRT). In the crossing of the Arabian Sea, the pipeline will reach water depths of around 3,400 m and will be around 1,300 km in length. An Offshore Gas Compression Station (OGCS) may be provided some 300 km from the Omani coast on top of the Murray Ridge where the water depth reduces to about 400 m.

Imported gas will play an important role in bridging the demand-supply gap in the Indian market. India imports around 26 mscmd of LNG. The country is short on natural gas. It needs around 180 mscmd, while the supply is 106 mscmd. This need for imported gas is recognized by earlier proposals to build land gas pipelines from Iran or Turkmenistan through Afghanistan or Pakistan to India but, despite years of discussion, these have not been implemented. Security of supply issues have become of increasing concern worldwide in the meantime, as evidenced in Europe recently when Russian supplies through third party countries to Western Europe were upset during peak demand periods.

Supply of gas from the Middle East to India has the additional benefit of easing gas transportation issues for producing countries like Turkmenistan, Iran and Qatar which will benefit greatly from the growing demand for natural gas in India, which will continue to exceed domestic supply capacity into the foreseeable future. The potential regional gas sources and pipeline route scenarios are presented in Figure 1.

The original Oman to India Pipeline project in the early 1990's highlighted a number of technical challenges:

- Pipe mill upgrades needed to manufacture the linepipe in the needed size and quality
- Lack of lay vessels with enough tension capability to lay pipes in 3,500 m water depth
- Incomplete understanding of seismic activities and mitigation methods for mudflows, fault lines and slope failures
- No qualified deepwater pipeline repair system available
- Significant hydrotesting and drying concerns

Even at that time however, these were not considered to be fatal impediments by the industry and three competitive bids were received and evaluated before the Omani-sourced gas was reassigned elsewhere. The massive growth in the Indian economy and rising gas prices there in the later half of the last decade has reopened this supply route option.

As shown in Figure 2, the offshore oil and gas industry has moved on significantly since 1995 and numerous large diameter gas transmission pipelines such as Bluestream and Medgaz, have been installed in depths up to 2,200 m and others are planned in circa 2800 m. Supply of natural gas to India by pipeline across the short and geopolitically neutral direct offshore route is the obvious solution to India's energy demands. It was held back 15 years ago solely by concern over the depth of the Arabian Sea. That impediment has now been overcome by the oil and gas industry and SAGE is poised to succeed.

The advances in design tools, manufacturing facilities and installation vessels since 1995 means that SAGE's MEIDP has a substantially lower business risk profile, specifically the following:

- At least three new generation large lay vessels are being built that are potentially capable of laying in 3,500 m water depths. These include

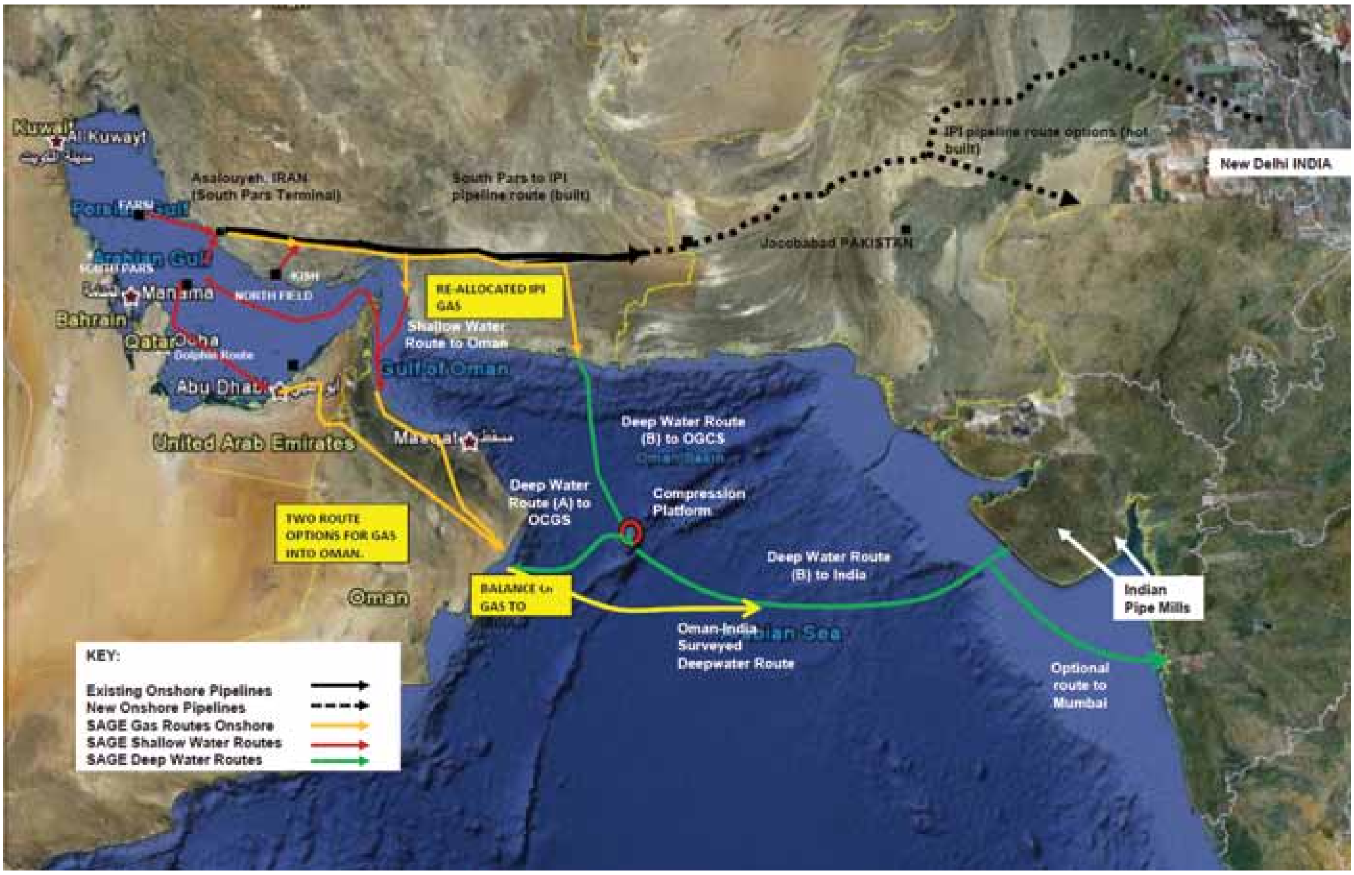

Figure 1. Potential regional gas sources and pipeline route scenarios

Saipem's Castoro One, which will be ready for work around the end of 2011.

» Several mills (including ones in India) can now manufacture pipe of sufficient size and quality to allow advanced design techniques to be adopted.

» New and improved design/mitigation methods for free-spans and geohazards will allow larger spans to be accommodated and minimize the need for deepwater intervention.

» Better survey and positioning capabilities during pipelay will accurately identify seabed hazards so that they may be avoided.

» Deepwater repair systems available have been developed and are available for deployment.

» New testing and commissioning philosophies are being developed (SAGE with DNV) to permit the use of higher fabrication factors during design and to remove the need for hydrotesting.

Peritus international is performing and supervising conceptual studies to move the project forward and take it into FEED in early 2012.

Pipeline Route

Many route options are under consideration. One option is shown in Figure 3. This route starts at the Middle East Compression Station (MECS) near Ra's Al Jifan in Oman. The route crosses the Gulf of Oman and the Arabian Sea to terminate at the Gujarat Pipeline Receiving Terminal (GPRT) near Porbandar in India, a total distance of about 1,300 km.

About 300 km along the route is the Qualhat Seamount. This dramatic feature rises almost 3,000 m from the seafloor to come within 300-400 m of the surface. It is an option to construct an Offshore Gas Compression Station (OGCS) on a platform on the Qualhat Seamount.

Figure 4 shows the route from the MECS to the OGCS. The route crosses the gently sloping Oman Shelf and then descends the relatively steep and fractured Oman Slope to the Oman Abyssal Plain. The Oman Slope is characterized by a stepping topography caused by faulting and it is incised by deep erosive submarine canyons and channels with steep walls. The Oman Abyssal Plain is generally flat, smooth and featureless.

After crossing the Oman Abyssal Plain, the route would ascend to the top of the Qualhat Seamount if the option to build the OGCS is selected.

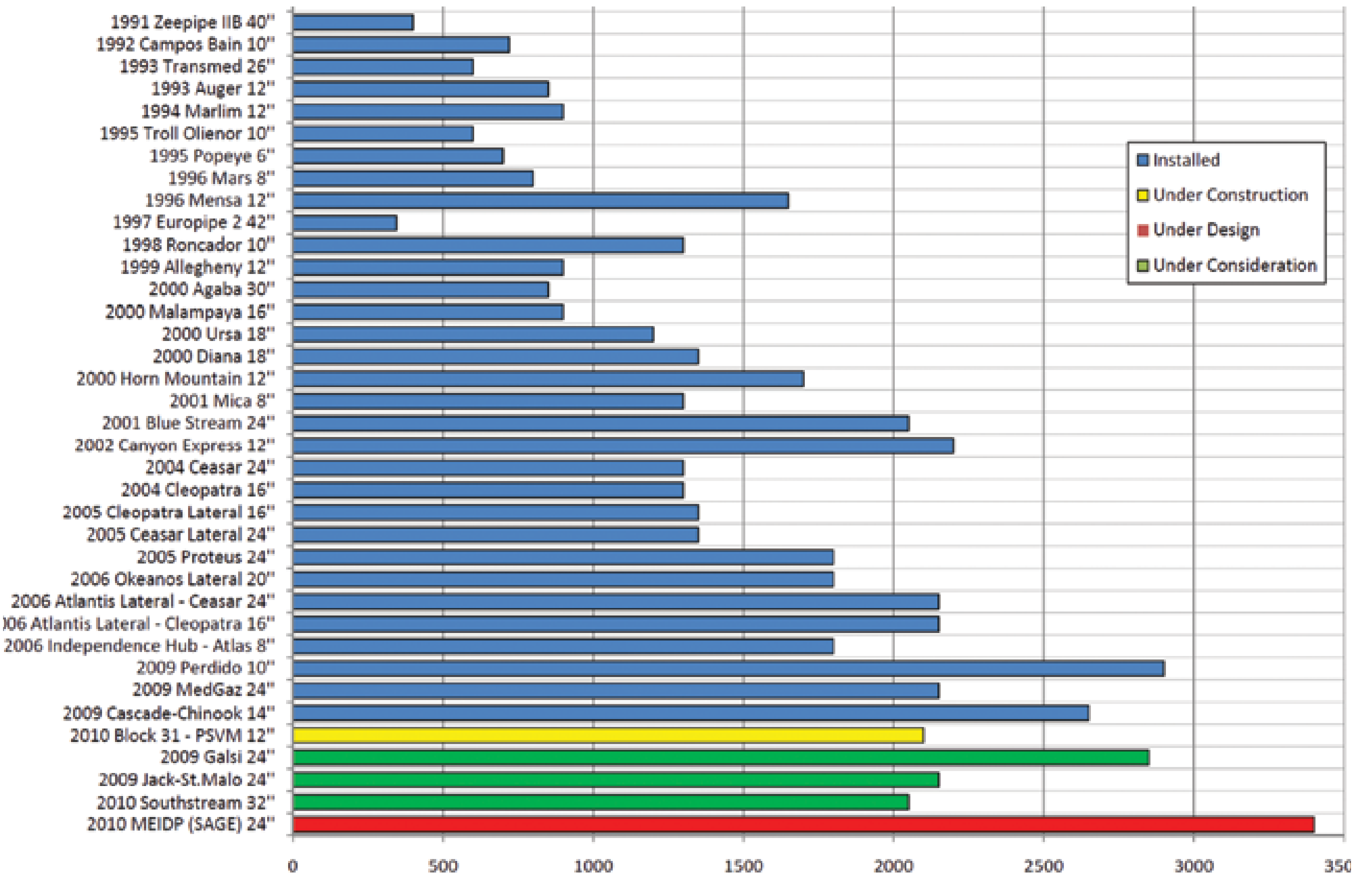

Figure 2. The drive into deeper water—year, pipeline, diameter and water depth (m)

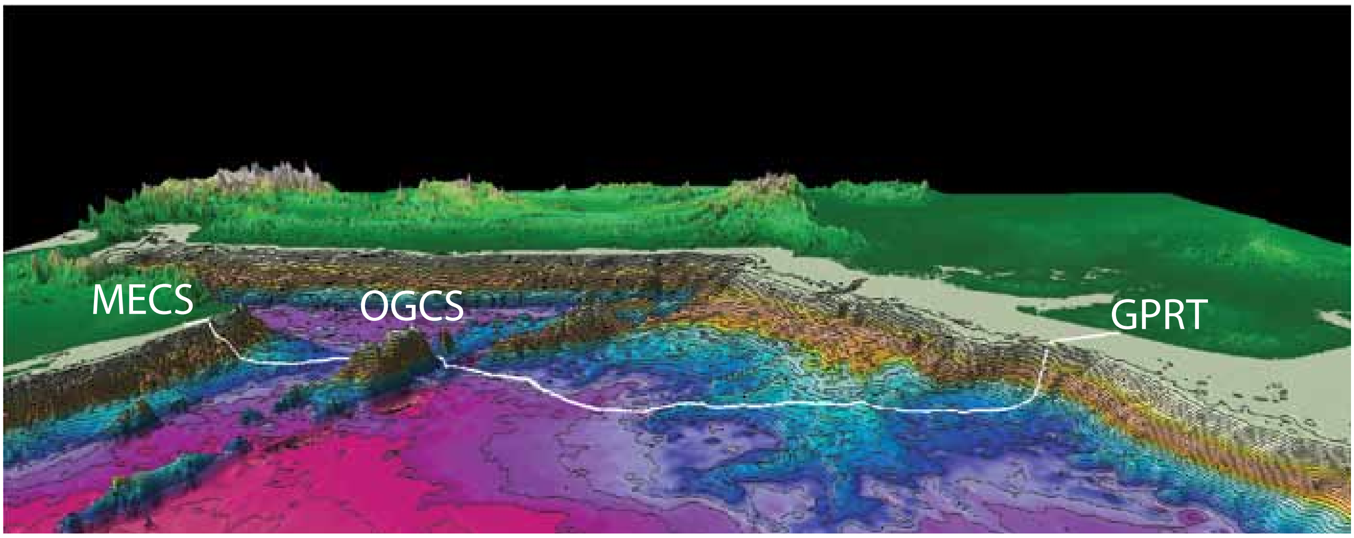

Figure 3. Pipeline route from MECS to GPRT via OGCS on Qualhat Seamount

The topographic feature containing the Qualhat Seamount is the Owen Fracture Zone and Murray Ridge. The feature contains ridges, seamounts, and deep troughs. It delineates the boundary between two tectonic plates that have relative horizontal movement. Earthquakes and fault movements occur along the Owen Fracture Zone and landslides are possible on the steep slopes of the ridges and troughs.

Figure 5 shows the pipeline route from the OGCS to the GPRT. The route descends the Qualhat Seamount to the seafloor following broadly the same route as for the ascent. On reaching the seafloor, the route turns and passes through a corridor between the Qualhat Seamount and a smaller seamount before crossing the tectonic plate boundary to enter the Arabian Abyssal Plain.

The route through the Arabian Abyssal Plain is generally flat, smooth and featureless except where it encounters the meandering channels and levees of the Indus fan. Finally, the route will climb the relatively steep Indian Slope and cross the Indian Shelf to the GPRT.

Quantitative Risk Assessment

A key factor in ensuring that the MEIDP is viable is the development of a robust technical risk profile for the project. In October 2010, a quantitative risk assessment (QRA) was commissioned for the project.

The QRA is a process of making a comprehensive assessment of hazards. The hazards being addressed include geohazards (earthquake, fault movement, landslide, turbidity currents, tsunami etc.), marine hazards (anchors, ship sinking, ship grounding, dropped objects, trawling, etc), internal and external corrosion, and material/construction defects.

Risk reduction measures for geohazards will

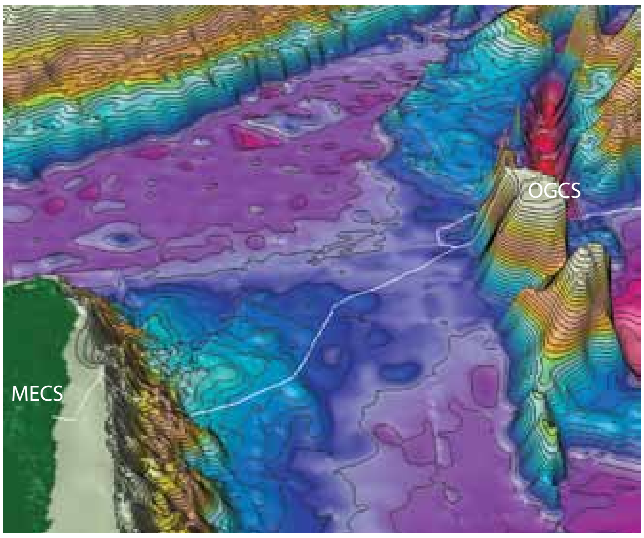

Figure 4. Route from MECS to OGCS

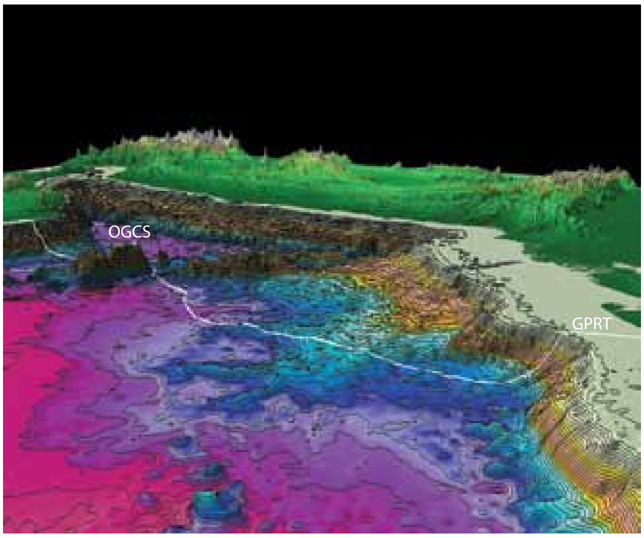

Figure 5. Route from OGCS to GPRT

include optimizing the route to avoid hazards as much as possible, routing down the fall line on steep slopes to minimize potential landslide loadings, and crossing fault zones at optimum angles to minimize pipeline stresses in the event of fault movement.

About 94% of the pipeline route will be on almost flat terrain where the risk from geohazards will be minimal. In the remaining 6% of the route, extensive geophysical and geotechnical investigations will provide data for sophisticated analytical studies to determine the likelihood and scale of potential slope movements so that all reasonably practicable avoidance or mitigation measures can be taken and the level of residual risk quantified.

On the Oman and India Continental Shelves, the pipelines will, like all pipelines in shallow water, be subject to the hazards of ship anchoring and ship grounding. These hazards have been minimized by locating the landfalls well away from major ports.

Trawling has been assessed to be an insignificant hazard due to the heavy wall thicknesses necessary for pressure containment in shallower water and for external pressure resistance in deeper water. Fishing studies will be performed to confirm trawl gear types and sizes and where appropriate concrete coatings will add to the pipeline's ability to accommodate trawling activities.

As for all pipelines, there will be minor risks due to ships sinking and dropped objects (typically containers lost overboard in heavy weather.

Internal corrosion will be a negligible risk since the pipeline will contain dry sales gas, the pipeline will be subject to intelligent pigging at intervals not exceeding 5 years, and the wall thicknesses will be heavy.

External corrosion is a very low risk for cathodically protected subsea pipelines. There are some special factors to be considered when designing CP systems for deepwater, where waters even in the tropics are very cold, but those factors are now well understood.

To avoid the risk of pressure collapse and buckle propagation in deep water, special quality requirements will be specified for line pipe, and SAGE is engaged in research with the steel mills to develop new improved methods for factory testing of line pipe. These measures will minimize the likelihood of significant material defects finding their way into operations.

The new generation dynamically positioned pipelay vessels presently under construction will have the top tension capacity needed to install pipelines in water depths up to 3,500 m and optimized motion characteristics to hold the pipeline steady during adverse weather conditions, so minimizing the risk of pipeline damage during installation.

The possibility of significant field weld defects entering service will be minimized by using best industry practices for weld quality control and inspection and testing. Preliminary results from the QRA indicate that the majority of the pipeline will be in a relatively quiescent and protected deepwater environment where the probability of events that can cause loss of containment will be very low. It is anticipated that the predominant risks will be in the shallow water nearshore zones, and similar in nature to those affecting any other gas transmission pipeline.